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ABSTRACT

An investigation examined the use of "preferred speeds" by young children in their response to a timing task. Three groups of boys, 5, 7, and 9 years old, made a simple horizontal arm movement that would end with contacting a microswitch at the same time a light reached the end of the runway. One stimulus traveled at the individual's preferred speed (predetermined during an initial session); four others were selected in .8 mph increments from that baseline preferred speed (two faster, two slower). The hypothesis was that subjects of all ages would perform most accurately when stimuli traveled at their preferred speed. Young children would be inaccurate at all other speeds, while older subjects would modify their response in relation to stimuli traveling at slow to intermediate speeds. As hypothesized, the 5-year olds responded accurately when the light speed matched their preferred speed. At other velocities, they either moved too quickly or too slowly. Seven- and 9-year old children were able to match their arm speeds to stimulus velocities up to and including their preferred speed. At higher velocities, they moved too slowly. Observation suggested that most children were attempting to use a rudimentary response strategy by 7 years of age. (Author/JM)

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AGE DIFFERENCES ON A COINCIDENT ANTICIPATION TASK: "PREFERRED" MOVEMENT SPEED AND RESPONSE STRATEGY USE

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Paper presented to the Research Consortium of the American Alliance for Health, Physical Education, Recreation and Dance, Minneapolis, MN, April 7-11, 1983

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ABSTRACT

This investigation was performed to describe and explain age-related limitations in response accuracy on a coincident anticipation task. Previous research had shown a consistent pattern of results for timing experiments: Young children respond early when stimuli travel slowly. They are late when stimulus velocities are fast; they are most accurate at intermediate speeds. Older children and adults are more accurate at slow to intermediate speeds; they are less accurate at fast velocities. Use of a preferred movement speed was hypothesized as one possible explanation for these results, particularly for the youngest children. Five, 7 & 9 year old boys were tested in this investigation. During an initial session, each individual's preferred movement speed was estimated. They performed a horizontal arm movement like one that would be used when performing the anticipation task. In a second session, individuals responded to stimuli produced by the Bassin Anticipation Timer. The children were asked to make a simple arm movement that would end with contacting a microswitch at the same time the lights reached the end of the runway. One stimulus traveled at the individual's preferred speed; four others were selected in .8 mph increments from that "baseline" preferred speed (two faster, two slower). As hypothesized, the 5 year olds responded accurately when the light speed matched their preferred speed. At other velocities, they either moved too fast, or too slowly. Seven and 9 year old children were able to match their arm speeds to stimulus velocities up to and including their preferred speed. At higher velocities, they moved too slowly. Observation suggested that most children were attempting to use a rudimentary response strategy by 7 years of age.

Age Differences in Coincident Anticipation: Preferred Movement Speed and Strategy Use. Kathleen Williams, University of Oklahoma

Successful performance of many physical skills relies on intercepting an object as it travels through space: The squash player must anticipate how a ball will richochet off a wall; a softball player must predict where a fly ball will go. This process of adjusting a motor response to the arrival of an object at a specific time and place is called coincident anticipation (Belisle, 1963).

Although adult anticipatory responses have been examined rather extensively, the study of age differences or changes in the timing of motor actions is a relatively new area of interest to motor development researchers. Previous developmental investigations have primarily described age-related improvements in accuracy (for example, Shea, Krampitz, Northam, & Ashby, Note 1).

A variety of stimulus conditions, and a wide range of stimulus speeds have been used by different investigators. Separate studies by Shea et al. (Note 1) and Williams (Note 3) illustrate a typical pattern of constant errors (Figure 1) across a range of stimulus velocities. These studies showed that, at slow speeds, 5 year olds were earlier in their responses than older children and adults (i.e., negative errors designate early arrivals, positive errors refer to late arrivals). The magnitude of their errors increased linearly with increased velocity. Overall, timing errors for older children were smaller than younger children, especially at slow to intermediate speeds. At higher speeds, the size of their errors also increased. Adults were generally more accurate than younger (here 5 & 7's) children, but their accuracy also declined at higher stimulus speeds.

Based on developmental information processing research (Gallaher & Thomas, 1980; Thomas, 1980), investigators have assumed that children would perform

timing tasks more accurately if stimuli moved slowly enough (Shea et al. Note 1). Since information processing studies have demonstrated that children process information more slowly than adults (Chi, 1977), increasing their response processing time (by slowing down the stimulus) should enable them to increase their accuracy. This prediction has not been confirmed by the data for timing tasks, however (Haywood, 1977; Shea et al. Note 1; Stadulis, Note 2). In fact, as demonstrated here (Figure 1), young children respond earlier at slow stimulus velocities.

While children's late responses at fast stimulus velocities may be related to limitations caused by slower information encoding then adults (Chi, 1977), it does not explain their early responses to slow stimulus speeds. A data analysis by Shea et al. (Note 1) may suggest a reason for this recurring pattern of results. Their subjects made a short arm movement, timed with a set of apparently moving lights. They measured their subjects' movement times across six equal segments to find out where (and if) subjects modified their movement speed when stimuli traveled at different velocities. Results showed that adults changed their speed to all but the fastest stimuli by the time the movement was only one-third completed. In contrast, the movement response was half completed before 9 year olds changed their speed. If 5 year olds changed their responses at all, the movement was already two-thirds completed. The only time they changed their speed was in response to the slowest stimulus. When subjects of any age did not modify their responses, they used a stereotypic arm speed, regardless of stimulus characteristics (although there were individual differences in these speeds).

The results just summarized suggested two things: 1) that the youngest children had large errors at fast and slow stimulus velocities because they rarely changed the speed of their response. They seemed to use the same, or

"preferred movement speed," regardless of stimulus characteristics; 2) older subjects modified their movement speed to all but the fastest moving stimuli. At the fastest speeds, they too "resorted" to using their preferred speed. This speed might be called more appropriately a "default speed" in these older children.

The present experiment was performed to examine the use of "preferred movement speeds" by young children in their responses to a timing task. It was hypothesized that subjects of all ages would perform most accurately when stimuli traveled at their preferred speed. Young children would be inaccurate at all other speeds, while older subjects would modify their responses in relation to stimuli traveling at slow to intermediate speeds.

Methods

Subjects

Three groups of male children, 5, 7, and 9 years of age, participated in this experiment (N=14 5 and 9 year olds; N=15 7 year olds). Parental permission was secured for each child.

Instrumentation and Experimental Task

Each individual's preferred movement speed was estimated in an initial testing session. Children performed 30 trials of a horizontal, left to right arm movement at their chosen or most comfortable pace. This movement was identical to the one that was to be used for the timing task. The final 21 trials were averaged to estimate preferred speed, since previous research (Smoll, 1975a,b; Williams, Note 4) suggested that subjects changed their movement speed over the first few trials as they "adjusted" to the task. Ideally, subjects would respond to two stimuli faster and two stimuli slower than their "baseline." An arbitrary cut-off point of .4 mph was selected, however, below which no

stimulus could fall. This cut-off resulted in some subjects who responded to three or four stimuli above their baseline.

The timing task was administered using a Bassin Anticipation Timer (Lafayette Instruments #50575A,ø). A single section of the runway (67.5 cm) was used, consisting of 16 "apparently" moving LED's, oriented horizontally, so that the lights "moved" from left to right. A frame was fitted over the runway, suspending two microswitches vertically at a height of 10 cm. The first ("start") microswitch was in line with the first LED, the second ("stop") microswitch was in line with the final LED.

During the performance of the timing task, starting position for each trial was with the right hand across the midline, depressing the "start" microswitch. Subjects released that switch and made a simple, horizontal movement to close the second switch. "Movement" of the lights began when the "start" switch was released. The goal was to time the movement so that contact with the "stop" microswitch occurred coincident with the lighting of the final LED. Ten trials each, of the five stimulus velocities, were administered to each child. Trials were given randomly in two blocks, with a two minute rest between blocks.

Design

The actual movement speed subjects used in response to their own set of stimuli was of primary interest in this experiment. For ease of discussion, these speeds have been translated into movement times. A movement time refers to the average time used by subjects to traverse the length of the runway. These were compared on a case by case basis and analyzed using a non-parametric Wilcoxin signed rank test for matched pairs. Each age group was analyzed separately.

Previous experimentation (Williams, Note 3, Exp. I) suggested that some

children and adults used specific, age-related patterns or "strategies" to "solve" the timing task. Constant error scores were analyzed in a simple effects ANOVA to explore the use of these strategies further. Finally, movement times were analyzed in another simple effects analysis in order to determine whether subjects had changed their movement speed in response to stimuli at different velocities.

Results

Selection of Stimulus Velocities

Across all subjects, preferred movement speeds ranged between .7 - 7.3 mph. The range and standard deviation was somewhat smaller for the 5 year olds as compared with the older children. The wide range of stimuli resulted in large standard deviations for some measures, however. Consequently, the homogeneity of variance assumption was presumed to be violated in certain analysis and will be discussed where it is relevant.

Arm Movement Times and Preferred Speed

If children use their preferred movement speed in performance of a coincident anticipation task, their movement times should match the runway time when the stimulus velocity matched their preferred speed. Runway time refers to the amount of time it takes for the lights to "move" down the runway. As hypothesized, 5 year olds' movement speeds matched stimulus speeds only at the baseline (Figure 2). At other speeds, they moved too fast or too slow relative to the stimulus: When the stimulus was slow, they moved too quickly; when the stimulus was fast, they went too slowly. Older children were more accurate over a wider range of stimuli than 5 year olds (Figure 2). Seven and 9 year olds were accurate at speeds slower than their baselines. For stimuli above the baseline, however, these children also moved slower than the runway lights.

To determine what arm movement speed children used in relation to each stimulus, a simple effects ANOVA was performed. The wide range of stimuli used in this study resulted in heterogeneous variances. Geisser-Greenhouse estimates were computed for these data and showed that 5 year olds always used the same movement speed although it approached significance for the slowest stimulus velocity ($F_{1,40}$=5.88, p=.019), (Figure 3). The 7 and 9 year olds clearly used different arm movement speeds in response to at least some stimuli ($F_{1,40}$=23.58, p=.00001; $F_{1,40}$=22.14, p=.00001, respectively).

Constant Errors for "Aligned" Stimuli

Children in this experiment seemed to be responding to at least the slowest stimulis in one of two distinct ways (Figure 4): Some arrived early at their slowest velocity; others were very late. Early arrivers were designated "non-strategic," while late responders were "strategy users". The simple effects ANOVA performed on these data showed that the groups differed at their slowest stimulus velocity and on no other ($F_{1,40}$=18.62, p=.0001). The strategy-using group was primarily 7 and 9 year olds; the non-strategic group was primarily 5 year olds. These results were consistent with an earlier experiment (Williams Note 3, Exp. I).

Discussion

In this experiment, children's movement speeds matched a stimulus' velocity when it traveled at the individual's preferred pace (Figure 2). That was the only time 5 year olds "adjusted" to the stimulus, apparently becuase they generally used one movement speed - their "preferred" speed. Older children (7 and 9 year olds) were able to change their movements in response to a wider range of stimuli. They matched velocities moving slower than, or the same speed as, their preferred speed (Figure 2). They "resorted" to a single speed for

all other, faster stimuli.

Accurate responses to timing tasks, like those used in this investigation, require a subject to make a movement which accounts for the speed of the s imulus. Observation of the older children and preliminary support from the data suggested that they used at least a rudimentary strategy in response to slow moving stimuli. Most of the 7 and 9 year old children apparently slowed down and waited for the slow moving lights. Then, they seemed unable to make sufficient additional adjustments that would result in increasing the overall accuracy of their performances (Figure 4). Although they had only limited success, these children seemed sensitive to the importance of trying to time some responses. They may have been unable to select an appropriate response, or once determined, there was insufficient remaining time for additional modifications. The net result of either possibility would be a late response by these children to their slowest stimulus.

On the other hand, the youngest children tested in this experiment seemed unaware of the importance of the timing aspect in their responses. Observation and questioning of subjects suggested that they simplified their task to one of just moving between the microswitches. That movement nearly always occurred at the same speed--their preferred speed.

The data from this experiment make it impossible to determine the precise locus of the children's inability to respond accurately. It has demonstrated however, that children use a single "preferred" or "default" movement speed when the task requirements exceed their ability to make the necessary adjustments. Young children almost always use the same speed; older children resort to it as necessary.

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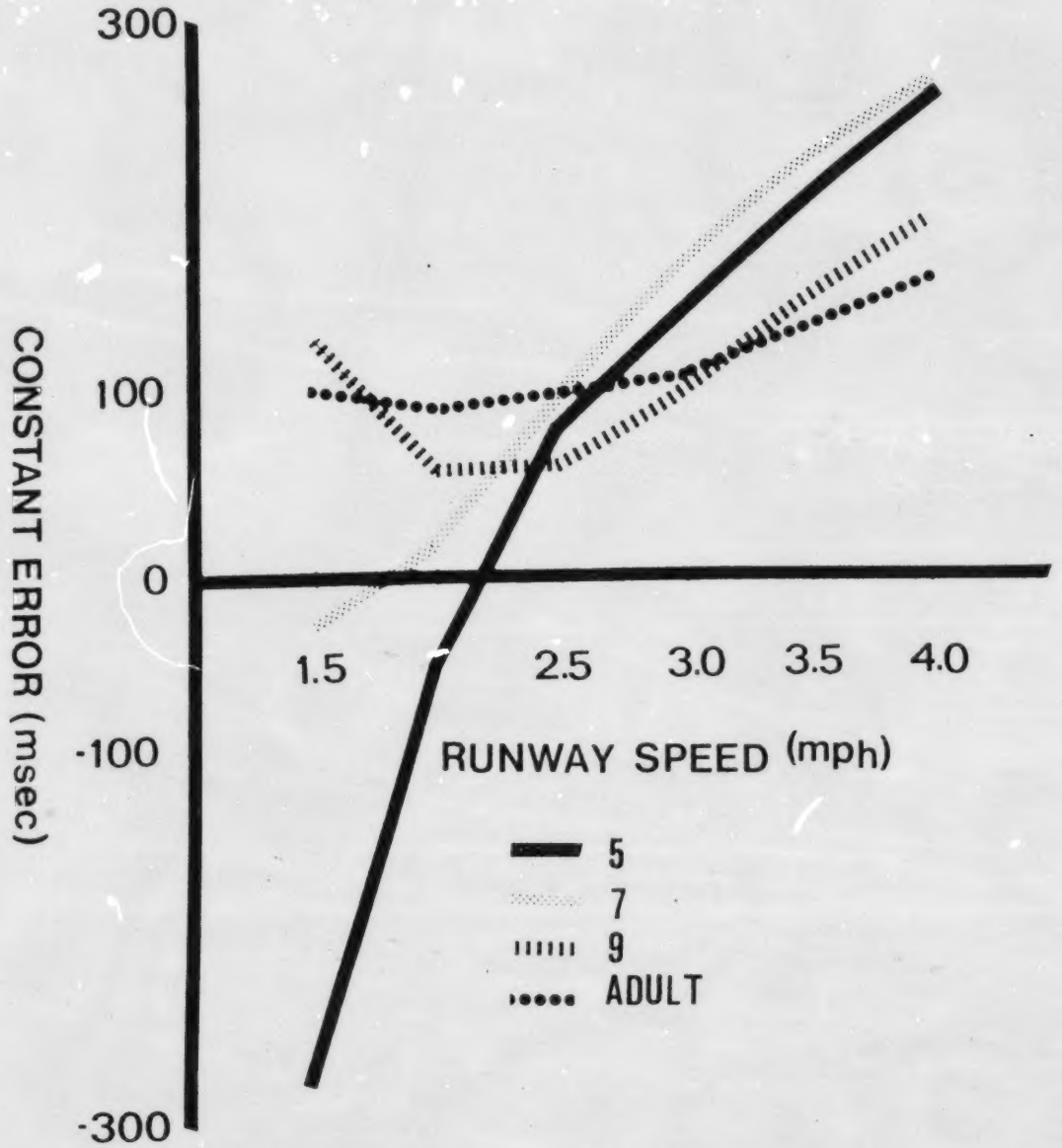
FIGURE CAPTIONS

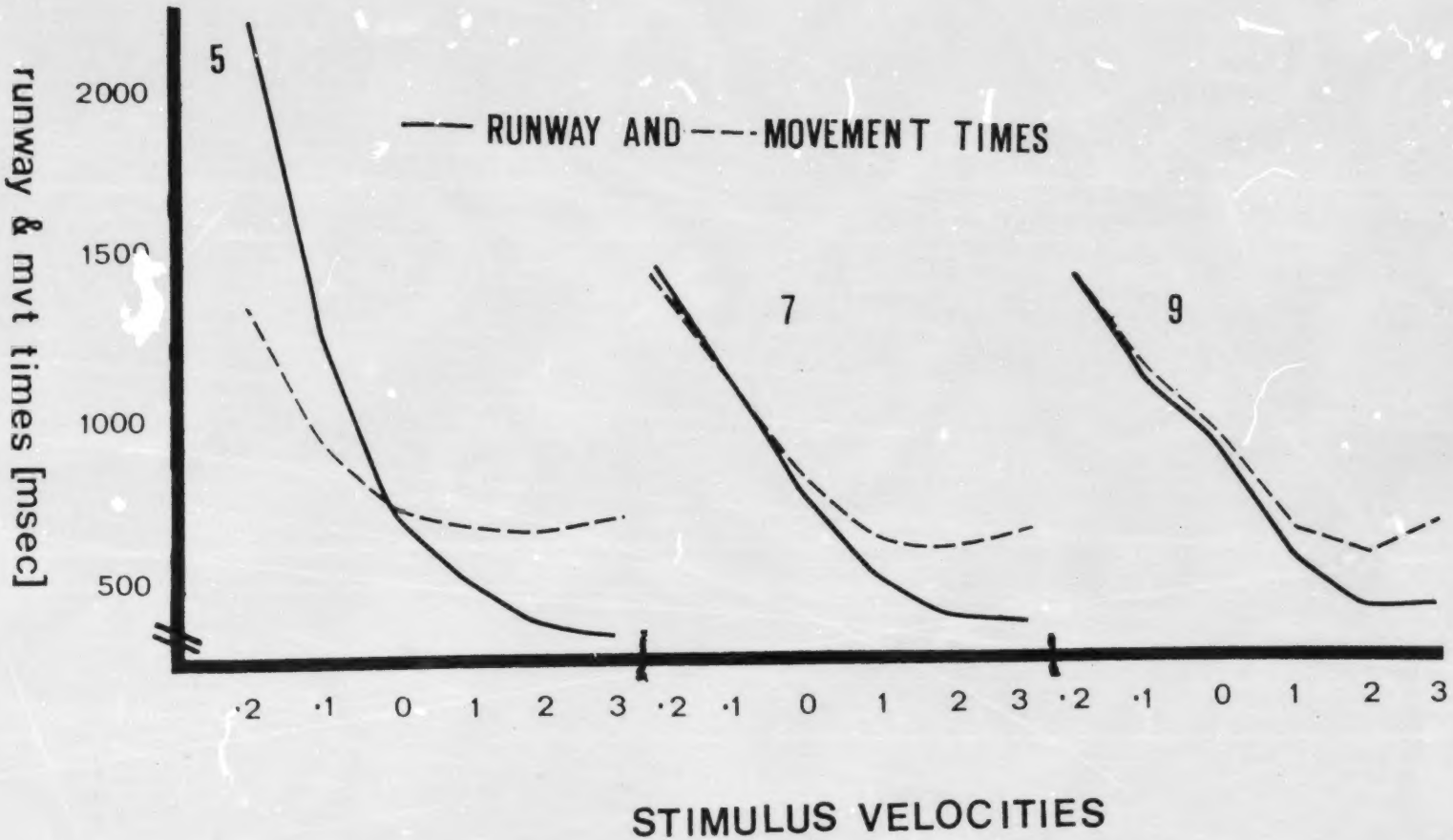
1. Constant errors (in msec) for 5, 7, and 9 year old boys and adult males for stimuli traveling between 1.5-4.0 mph.

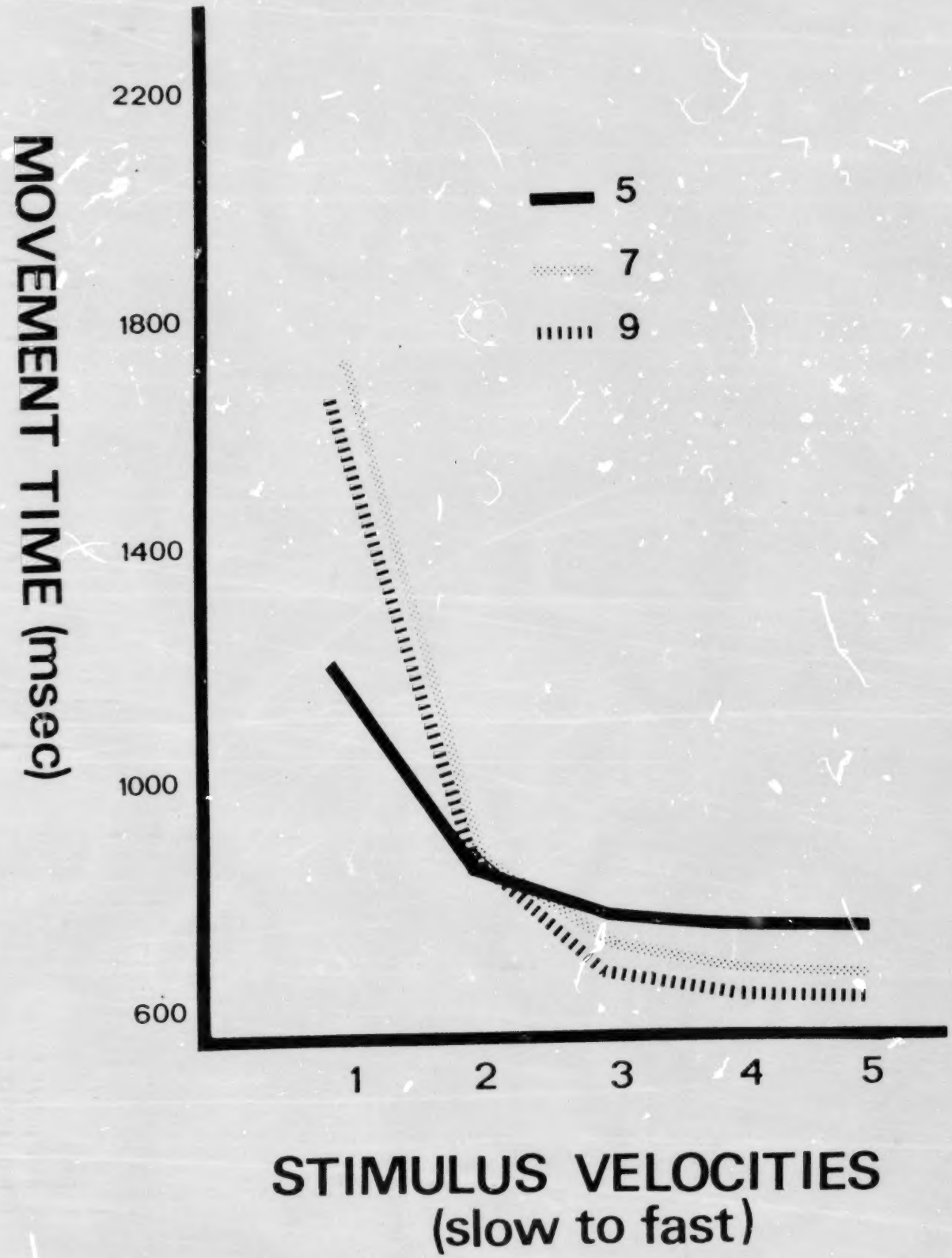
2. Comparison between runway and movement times for 5 year olds (left panel), 7 year olds (center panel), and 9 year olds (right panel) for stimulus velocities arranged in relation to baseline preferred speeds (0). Stimuli are incremented (+1, +2) and decremented (-1, -2) in .8 mph units from the baseline.

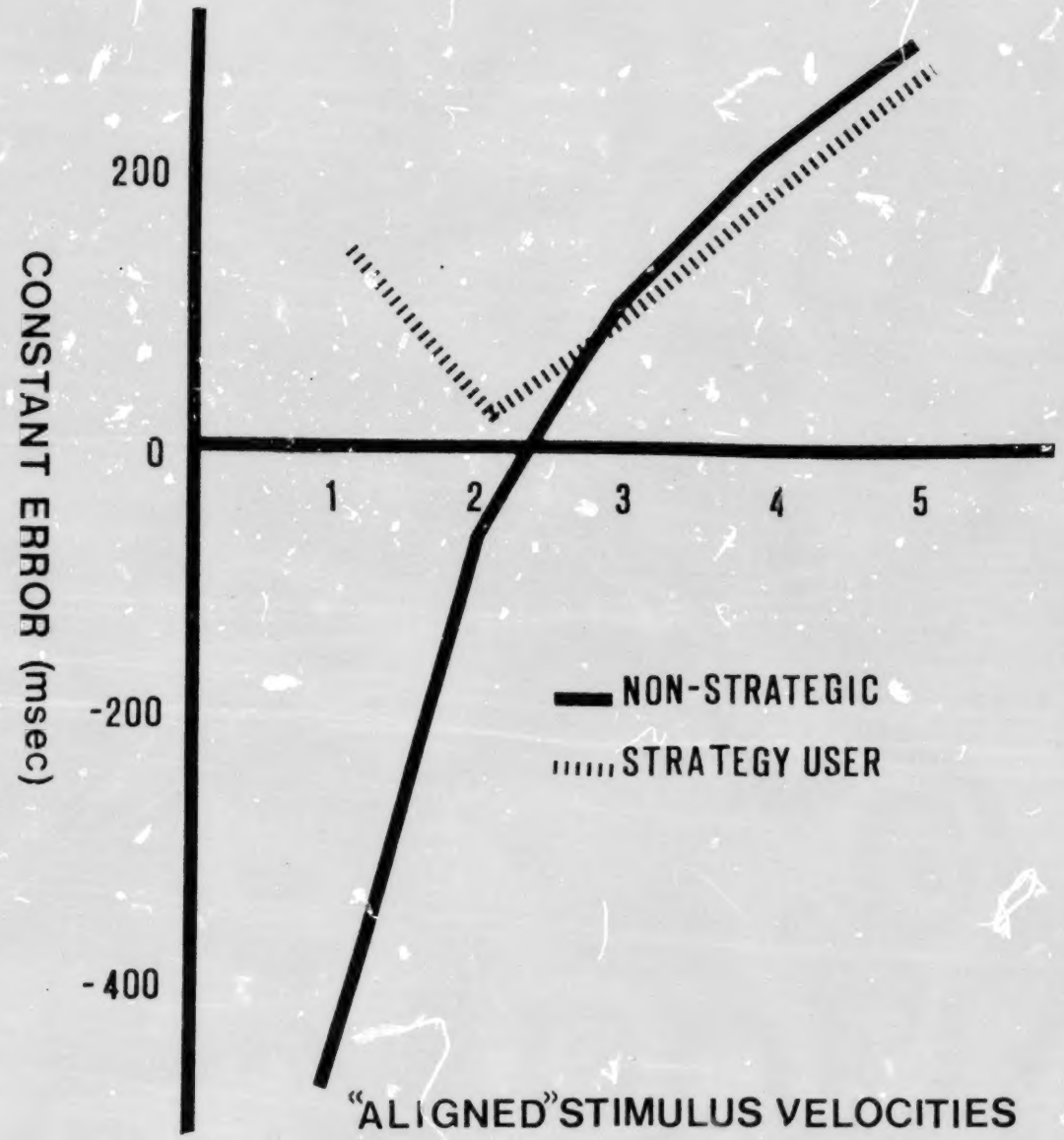
3. Movement times (in msec) for 5, 7 and 9 year old boys for stimulus velocities arranged from slowest to fastest (without regard for baseline stimuli).

4. Constant errors for 5, 7 and 9 year old boys grouped by strategy use or non-use. Stimuli have been arranged from slowest to fastest, without regard for baseline stimulus velocity.


300
100
0
-100
-300
CONSTANT ERROR (msec)
1.5
2.5
3.0
3.5
4.0
RUNWAY SPEED (mph)
5
7
9
ADULT


runway & mvt times [msec]
2000
1500
1000
500
5
7
9
RUNWAY AND MOVEMENT TIMES
·2 ·1 0 1 2 3 ·2 ·1 0 1 2 3 ·2 ·1 0 1 2 3
STIMULUS VELOCITIES


MOVEMENT TIME (msec)
2200
1800
1400
1000
600
5
7
9
1
2
3
4
5
STIMULUS VELOCITIES
(slow to fast)


200
0
-200
-400
CONSTANT ERROR (msec)
1
2
3
4
5
NON-STRATEGIC
STRATEGY USER
"ALIGNED" STIMULUS VELOCITIES